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A Palm™-based digital field-data capture system

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Abstract: To expedite delivery of the digital geological products of new fieldwork, digital capture of point observations must occur on the outcrop in order to expedite the population of a database while the mappers are still in the field area. A variety of currently available handheld devices and software has been evaluated for this purpose, and a robust, efficient digital data-collection process has been developed. Using Pendragon Forms™ 3.0 data-collection software, we have created an electronic data-collection 'form' for the Palm™ model IIIe handheld device. The mapper completes a data form at each outcrop; upon completion of the traverse, the data are downloaded to a database in camp for immediate visualization using a GIS. Data verification and preliminary interpretation can occur in the field, and production of products for publication can begin immediately.

Résumé : En vue d'accélérer la livraison des produits géologiques numériques découlant de nouveaux travaux de terrain, la saisie numérique des observations ponctuelles doit être réalisée à l'affleurement même afin d'accélérer l'alimentation d'une base de données pendant que les cartographes sont encore sur le terrain. Divers appareils portatifs et logiciels ont été évalués à cette fin, et une méthode efficace et solide de collecte des données numériques a été mise au point. À l'aide du logiciel de collecte de données Pendragon Forms 3.0, nous avons créé un «formulaire» électronique de collecte de données à utiliser avec l'appareil portatif Palm™ modèle IIIe. Le cartographe remplit un formulaire à chaque affleurement; une fois la traverse complétée, il télécharge les données vers une base de données au camp de terrain pour visualisation immédiate à l'aide d'un SIG. La vérification et l'interprétation préliminaire des données peuvent se faire sur le terrain, et la préparation des produits à publier peut commencer immédiatement.

INTRODUCTION

The capacity to digitally capture geological observations while on an outcrop, and contribute them upon completion of the traverse to a central database in the field camp, is the foundation upon which expeditious production of geological maps is based. The digital field-data capture system must be physically robust, as well as easy to learn and operate. In preparation for launching a new generation of regional geological mapping initiatives that would produce digital products (maps, databases) promptly following completion of fieldwork, and involve managing daily data input from up to 12 mappers per project, various digital systems for the collection and management of geological point data were examined. A variety of handheld devices (personal digital assistants), operating systems, and software combinations were evaluated. Compatibility of the digital output with the ArcInfo™ geographic information system (GIS) software that would be used to manipulate the data and produce maps was a prime consideration, as were device availability, initial learning curve, ease of use, field ruggedness, downloadability, and cost.

Following an evaluation of the broad spectrum of handheld devices available in March, 2000, we selected Palm IIIe™ devices running Palm OS® 3.0, and Pendragon Forms 3.0 data-collection software. Using Pendragon Forms 3.0, a digital data-collection 'form' was developed for data input on the outcrop. This basic form was customized for use in each of our multidisciplinary mapping projects. In the following sections, we describe the criteria by which this combination of hardware and software was selected, the structure of our digital data-collection form, operation of the system on the outcrop, and data downloading and database-population procedures.

HARDWARE

We evaluated a wide variety of currently available handheld devices, commonly known as personal digital assistants or electronic organizers. Data input on such devices falls into two categories according to input interface — those with conventional but miniature alphanumeric keyboards, and pen-based devices that feature a touch-sensitive liquid crystal display (LCD) screen. In light of anticipated field operating conditions and the nature of the data to be collected, the pen-based category of devices was determined to be more suitable, and a range of devices was chosen for further evaluation.

Commonly available pen-based devices can be broadly divided into two groups based on operating system (OS). The first group uses the Windows® CE 2.0 OS, and included the Casio® Cassiopaea E-105, the Compaq™ Aero 2100, and the Philips® Nino 500. The second group, using the Palm OS, included Handspring™ Visor™, and several models manufactured by Palm Computing Inc. A wide variety of data-collection and -management software applications is available for each of the operating systems.

Comparison of efficiency of operation (OS and software application function, battery life) and ease of data transfer to a central database (downloadability) favoured Palm OS devices over those running Windows CE. Monochrome displays were found to be easier to read under a variety of outdoor lighting conditions, permitted longer battery life, and are substantially less expensive than colour displays. We tested three monochrome Palm models with various levels of storage capacity (static RAM) and cost: a model IIIe with 2 Mb, $219; a model IIIx with 4 Mb, $339; and a model Vx with 8 Mb, $499. The operational performance of the three models was indistinguishable, and, as outlined below, 2 Mb of memory was found to be an order of magnitude more than was required to store the data collected during an individual traverse. Consequently, we developed our digital field-data capture system for use on the Palm IIIe device (Fig. 1a). Each handheld device was 'ruggedized' for fieldwork using a semi-rigid neoprene protective case (Palmsuit by Rhinoskin™, $29) (Fig. 1b).

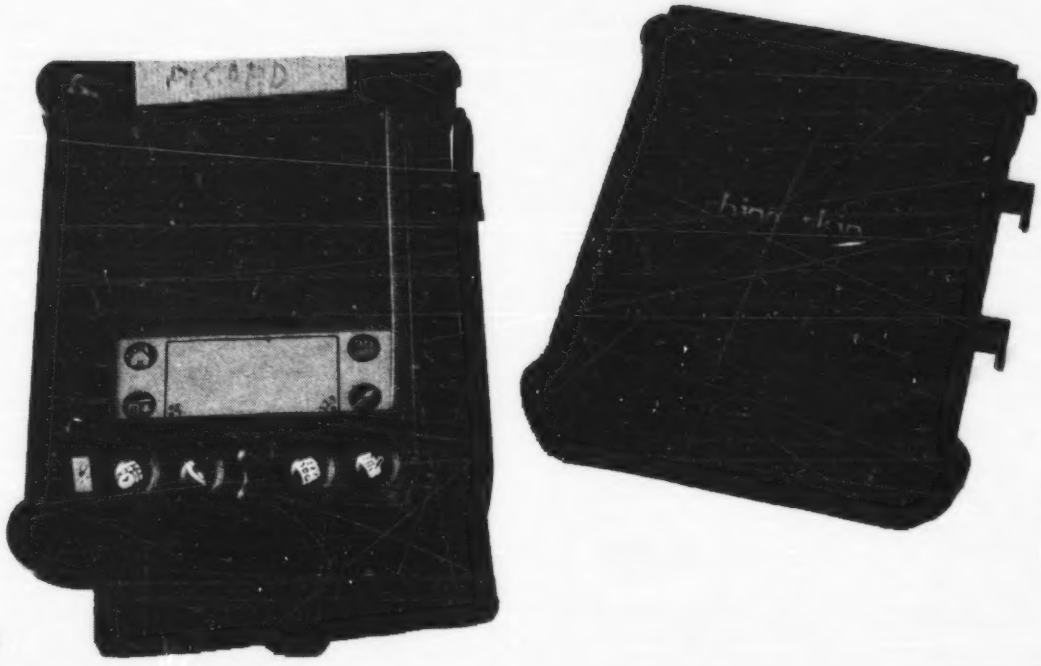
SOFTWARE

We evaluated a variety of software applications that are capable of managing alphanumeric data, including a spreadsheet application (QuickSheet™, Cutting Edge Software), two 'shareware' data gathering applications, (DDH Software's HanDbase and Land-J's JFile) (Pogue, 1999), as well as the commercially available Pendragon Forms 3.0 data-collection and management application. A test spreadsheet 'form' was found to be inefficient in terms of storage (empty cells) and data entry. Both of the shareware data-gathering applications were found to be limited in number of fields (16) and data structure. A demonstration version of Pendragon Forms 3.0 for the Windows (95, 98, or NT) desktop platform was found to have sufficiently flexible data structure, convenient data entry modes (pick list, multi-pick list, check box, numeric, freeform text), and user-friendly programmability for our intended application. A full feature copy of Forms 3.0 was purchased for $199; licenses to install Forms 3.0 for use on multiple Palm units cost $30 each.

DATA COLLECTION USING PENDRAGON FORMS 3.0

We created a generic geological data-collection form (Fig. 2) that consists of a main 'page' and numerous linked thematic pages (Structure, Rocks and Minerals, Samples and Photos), collectively termed a 'project'. Although our form is designed specifically for bedrock mapping activities in the Precambrian Shield, the content of the form can be readily changed to suit a wide variety of bedrock or surficial geological mapping needs. Additional structural elements, rock types, minerals, or texturaldescriptors can easily be added to picklists as mapping progesses and needs evolve; inappropriate elements can be deeted. The basic structure of our form can be used as a template to construct a new form for drill-core logging or measurement of stratigraphic sections.

a



b

Figure 1. ***a****) Palm Computing Inc.'s model IIIe, shown actual size. Touch-sensitive LCD screen measures 5.7 by 7.8 cm.* ***b****) Palm IIIe in Rhinoskin's Palmsuit semi-rigid neoprene protective case.*

Tombstone information, such as identity of the mapper, date and time of observation, geographic location, and waypoint, is gathered in the main page, as are any general comments the mapper may wish to add as text (Fig. 2). Once selected from the picklist, the identity of the mapper is retained as a default. Date and time are automatically captured from the OS; the time is entered into a 'blind' data field that is hidden from the user during completion of the form. The identity of the mapper, date, time, and geographic location are combined into a unique identification string for each record, and written to a hidden field. In order to help manage data input and track possible hardware problems, each Palm device in the fleet of each field project was assigned a unique name; the device name was recorded in a hidden field in each record. The outcrop or waypoint number, manually set to 1 at the first outcrop of a traverse, is automatically incremented each time a new main page is selected.

Geographic location is determined by handheld GPS receiver. The UTM zone is selected from a picklist and remains as a default until changed. The easting and northing values (X and Y co-ordinates) are entered manually using the on-screen touch-sensitive keypad (Fig. 3) or by writing numerals on-screen using the Palm's character-recognition capability. Whereas a GPS unit that connects directly to the Palm's data port is available (Earthmate® GPS by DeLorme®), we opted for manual data entry, as this allows the use of any model of GPS receiver as well as improved ergonomics. The range of eastings and northings for a given project area can be used to define the set of permissible user-entered values, offering a first-order level of error checking. Geographic co-ordinates must be successfully entered before the mapper can proceed with data entry, ensuring that all subsequent data are georeferenced.

THEMATIC PAGES

Navigation between and within the main and thematic pages in the project occurs by touching a series of on-screen, touch-sensitive directional arrows and 'buttons' (Add, End, Done). Entered data are saved to memory each time the user advances to a new field. Data can be reviewed and edited by navigating to and selecting the appropriate field in the form. These changes are automatically saved as the user moves on to other fields or pages.

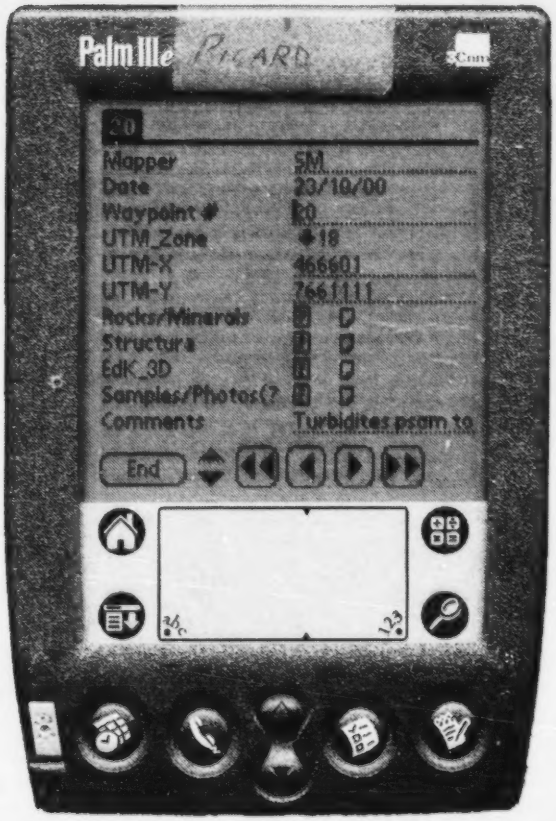


Figure 2. *Main page of geological data-collection form.*

Figure 3. *The on-screen touch-sensitive keypad used for numerical data entry.*

Rocks/Minerals thematic page

Access to the thematic pages is obtained by selecting the name of theme from the main page. The initial mandatory selection on this page in our form is from one of three broad classes of rocks: 'Plutonic', 'Sedimentary', or 'Volcanic' (Fig. 4a). These categories can easily be changed to suit mapping projects in other geological terranes. A detailed picklist of individual rock types is linked to each of the three broad class selections (Fig. 4b). An unlimited number of rock types can be described and recorded at an individual outcrop/location. Within a class, the mapper selects a rock type (e.g. monzogranite, pelite, basalt); accessory minerals are selected from a picklist that is linked to each rock type (e.g. magnetite, sillimanite, actinolite, respectively). Mode of occurrence (e.g. minor, dyke) is selected from a picklist; minerals of possible economic interest (chalcopyrite, sphalerite) are selected from a multi-picklist (Fig. 4c). Numerous textural adjectives can be selected from a multi-picklist (gneissic, megacrystic) to describe each individual rock type at the outcrop. For one of our field projects, we customized the Rocks/Minerals main page to include a field for recording magnetic susceptibility as measured on the outcrop. Finally, there is a text field for any general comments that the mapper may wish to add about rocks and minerals at each location.

Structure thematic page

We have organized this thematic page into 'Planar' and 'Linear' fabric elements — the user must select one type of element to proceed with data entry (Fig. 5). The fabric element to be described is selected from a picklist that is linked to the initial selection: 'Planar' prompts choices such as 'foliation' or 'gneissosity'; whereas 'Linear' offers 'S-fold hinge' or 'mineral lineation'. Numerical values for strike or trend (range limited to between 0 and 359) and dip or plunge (range limited to between 0 and 89) of the feature is entered using the keypad or on-screen character recognition. An additional text field is available for comments pertaining to the structural element that has just been recorded. This procedure can be repeated for each fabric element observed at an outcrop.

Samples/Photos thematic page

At outcrops where the mapper wishes to collect specimens, take photographs, or assign a station number, the Samples/Photos thematic page can be accessed. Station number is automatically incremented from the previous value, and combined with a predefined code that identifies the mapper to create a unique name for the station. If samples are collected, a unique letter is assigned to each (A, B, etc.), and the same descriptive fields as per the Rocks/Minerals thematic page can be completed. If photographs are taken, the roll and exposures numbers can be recorded. An additional text field is available for any comments.

Primitive sketches can be made on the Palm using Dinky Pad or similar software applications. The user can make a simple bitmap drawing using a variety of tools (pen, paintbrush, eraser); a checkbox on the Samples/Photos thematic page can be used to indicate that a sketch has been made at this location. To complete data entry on the main and thematic pages, the mapper activates 'Finished Stop?' checkbox, and selects the 'End' button. The process is repeated at the next outcrop by selecting 'New' from the project menu.

POPULATING THE DATABASE

One advantage of the Palm handheld platform is ease of connectivity. Each Palm device ships with a 'cradle' that connects the handheld unit to a PC (laptop or desktop computer, Windows or Macintosh) via the PC's serial port. The connection or 'conduit' between the two devices can be configured such that traverse data are removed from the handheld device and appended to the database resident on the PC at the touch of single button. This data transfer procedure is known as a performing a 'HotSync®' operation.

During the HotSync operation, the data contained in the main and three thematic pages are transferred to the Pendragon Forms 3.0 'Forms Manager' window on the PC. Tombstone information for each outcrop location (waypoint), including information that was automatically generated and written to hidden fields, is entered as a record in the Main database. The tombstone information is automatically propagated to each of the three thematic pages to create four nonrelated databases (Main and three Thematic). The hidden-field functionality could be used to automatically add look-up values for colours or symbols, or additional information needed for conformity with a higher level data model. Each rock type that has been described is listed as a record in the Rocks/Minerals database; similarly, each structural feature and specimen or photograph location is stored a record in the Structure and Samples/Photos databases, respectively. Once in the Forms Manager, the individual tables can be exported as either ASCII text files (.txt) or Microsoft® Excel files (.xls), allowing for a wide range of flexibility in working with GIS software packages (e.g. ArcInfo™, ArcView®, MapInfo®, GRASS®, etc.).

In order to perform daily, initial verification of the accuracy of the data, we converted each of the four tables into ASCII format, and imported them to a pre-existing ArcView project. A visual verification can be conducted by comparing plotted data over topographic and hydrographic background layers with data hand-plotted on air photographs during the traverse. If discrepancies are detected, complete information about the errant point(s) can be displayed immediately using the GIS. As the records in the Forms Manager are fully editable, corrections at the source can be performed with little difficulty, and the revised data reverified.

Figure 4. ***a)*** *Rocks/Minerals thematic page of geological data-collection form (complete form available by scrolling up/down)* ***b)*** *RockType picklist showing some of the available choices (complete list available by scrolling up/down)* ***c)*** *Mineralization multi-pick list.*

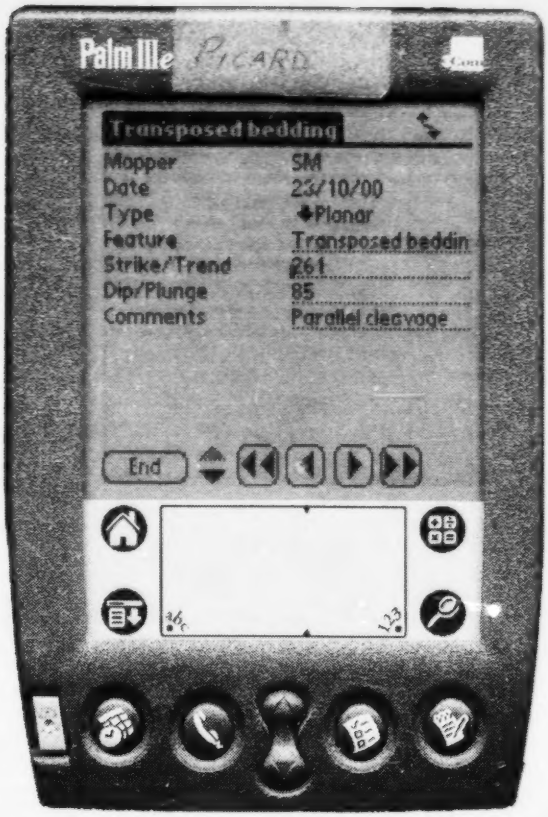


Figure 5. *Structure thematic page of geological data-collection form with data.*

DISCUSSION

The digital field-data capture system described here has allowed us to meet the point-data input requirements of our field projects, and consequently expedite production of digital maps and databases. We found that new users of the system, most with little or no previous knowledge of Palm devices or data-gathering software, were able to master the system in a very short period of time. For our mapping projects, in which up to 12 mappers were contributing data daily, this combination of hardware and software was found to be reliable, efficient, and affordable.

We would be pleased to provide additional documentation and a copy of our Pendragon Forms 3.0 data-capture project to interested readers. We foresee ongoing development of the geological mapping project described here, and creation of derivative projects that could facilitate data recording during measurement of stratigraphic sections and logging of drill core, and mapping of surficial materials.

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